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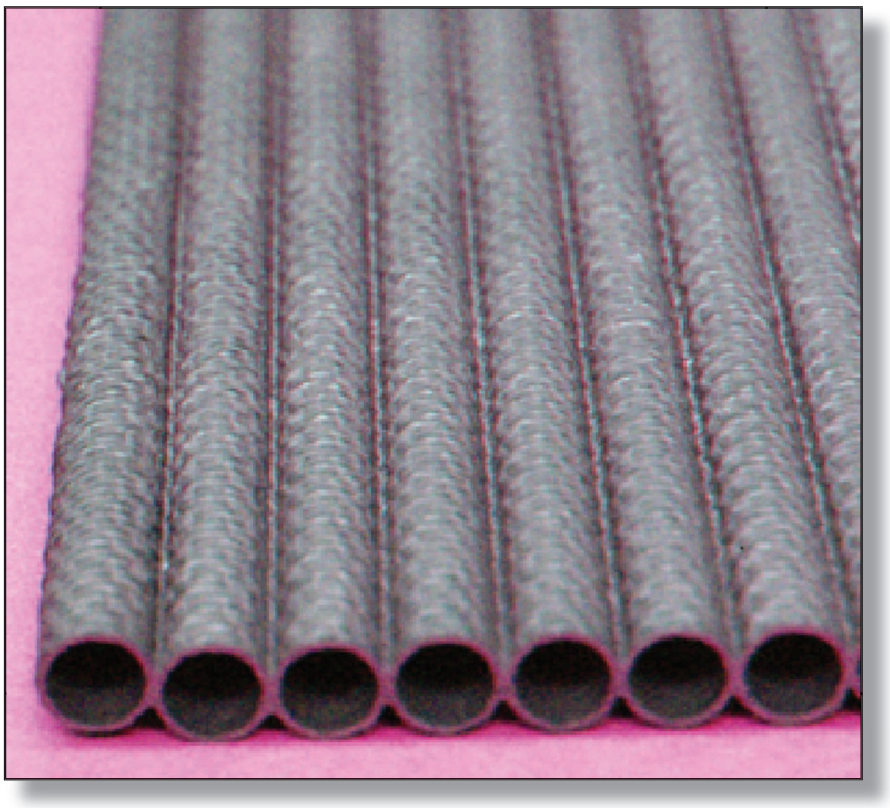
Science and Technology for Tomorrow's Air and Space Force

Success Story

RESEARCHERS DEVELOP INTEGRALLY WOVEN CERAMIC COMPOSITE STRUCTURES TO REDUCE WEIGHT OF NOZZLES FOR LIQUID FUELED ROCKET ENGINES



Integrally woven ceramic matrix composites for liquid-fueled rocket engine nozzles have the potential to reduce the weight of the nozzle by up to 50% and reduce the cost of the nozzle by up to 20%. Current nozzles, made from conventional stainless steel and nickel-based alloys, are very heavy structures. They are also expensive, using costly tube-forming operations, and brazing and welding processes in their construction.

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Accomplishment

Scientists and engineers at the Materials and Manufacturing Directorate partnered with the Rockwell Scientific Company and Boeing-Rocketdyne to develop ceramic materials and manufacturing processes as part of the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program for use in actively cooled rocket nozzles for next-generation, reusable launch vehicles. Directorate researchers expect nozzles constructed from advanced ceramic composites to have high strength at high temperatures and to be lightweight and reusable for multiple launches.

Background

In a liquid-fueled rocket engine, the engine injects a fuel and oxidizers into a thrust chamber where they mix and react. The fuel/oxidizer reaction produces high-temperature gases, which expand through a bell-shaped nozzle to produce thrust. Manufacturers currently make nozzles from conventional stainless steel and nickel-based alloys.

Nozzle walls consist of many small tubes through which coolant can flow to keep the nozzle materials from melting. The nozzles are heavy, complex, and expensive and require large amounts of cooling. Researchers collaborating as part of this IHPRPT program expect to demonstrate high-temperature materials that can significantly reduce the weight and cost of nozzles.

The directorate partnered with Rockwell Scientific Company to fabricate lightweight nozzle sections. The nozzle sections consist of a silicon carbide matrix reinforced with a carbon fiber preform (C/SiC).

A key attribute of this technology is the special weaving process that allows optimum placement of the carbon reinforcing fibers. The Rockwell Scientific Company integrally weaves the fibers into an entire tube-wall panel in a single piece, as opposed to single tubes constructed separately and then joined together as is the case for the conventional metallic tube-wall nozzles. This simplifies nozzle construction and results in a strong component with fewer joints.

In the future, Rockwell Scientific Company will join the separate nozzle sections together to form a small-scale, bell-shaped nozzle. Researchers will test the nozzle in an actual rocket environment at the National Aeronautics and Space Administration is Glenn Research Center's rocket test facility.

The goal of the current effort is to make the bell-shaped, tube-wall nozzle structure from a lightweight ceramic composite. Not only will the nozzle be lightweight, but because ceramics can withstand higher temperatures than metals, the nozzle will require less cooling, thereby improving performance.

Materials and Manufacturing
Emerging Technologies

Additional information

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